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## Strategy Uses and Study Time: Relationship with Memory Performance in Older Adults

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STRATEGY USES AND STUDY TIME:  
RELATIONSHIP WITH MEMORY PERFORMANCE IN OLDER ADULTS

by

Karen A.S. Doolittle

A Thesis Submitted to the  
Department of Human Factors and Systems  
In Partial Fulfillment of the Requirements for the Degree of  
Master of Science in Human Factors and Systems

Embry-Riddle Aeronautical University  
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by

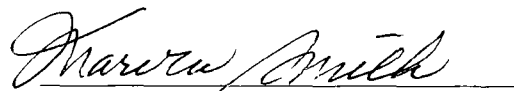
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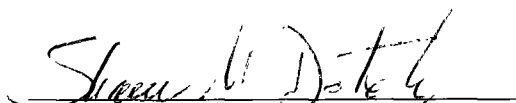
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## ABSTRACT

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The overall purpose of this study was to foster a greater understanding of age-related memory loss as it pertains to the aging workforce's ability to remain productive and effective in a time of complex change, and to recommend some adjustments that can be made to compensate for these memory declines. The specific intent of this current project was to test one premise of Ericsson and Chase's Skilled Memory Theory, namely that memory skill is a skill that can be developed through enhanced encoding and through practice. By introducing participants to the simple mnemonic strategy of chunking and by allowing two different study times, it was hypothesized that recall would be higher for the groups instructed to use the chunking than for the no-strategy group. It was also hypothesized that the group given the longer study time would outperform the group given the shorter time. Results of the study did not support either hypotheses.

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## INTRODUCTION

Historically, old age was something only experienced by a limited few, yet over the past few decades demographic aging has become more apparent. People today are often living well into their 70s and 80s. Figures show that in the 20<sup>th</sup> century, 30 years were added to the average life expectancy of Americans (Carstensen, 2001). We are living in a society that is demographically older than any we have ever known. It is predicted that the median age, not only in America but also in most developed countries, will reach 51 by the year 2050 (Peterson, 2001). As the general population ages, we are finding more and more individuals remaining in the workforce well into their later years. Between 1985-1995, the number of workers age 65 and older increased 31%, more than twice the percentage increase in the overall workforce for that period (Nayer, 1997). This change in the age composition of the workforce is not only due to the increase in life expectancy, but also due to the decline in the mortality rate, lower birth rates, economic/personal factors, anti-age discrimination laws, federal legislation rescinding mandatory retirement, and by the removal of Social Security penalties reinforced by Clinton's "The Senior Citizens' Freedom to Work Act" (McMahan & Phillips, 1999). Additionally, it is interesting to note that during the 1980s and 1990s, the number of new (first-time) workers entering the workforce declined by 37 % (Lofgren, 1999). This aging of the workforce finds organizations and managers faced with a new set of challenges as older workers have different needs than their younger counterparts. These needs should be addressed if it is management's goal to supply workers with what they need to optimize performance levels. While there may be numerous 'special needs' that could arise with an aging worker, the current project will not be addressing those. The purpose of this research is to foster a greater understanding of age-related memory loss as it pertains to the aging workforce's ability to remain productive and effective in a time of

complex change and to promote a better understanding of some of the adjustments that can be made to compensate for these memory declines.

### Cognitive Declines

To better understand memory declines, it is important first to understand the overall cognitive declines that occur with age. In his extensive research, Salthouse (1991) identifies four processing resources that seem to account for much of the age difference in cognitive functioning. They are (1) the speed of information processing, (2) working memory function, (3) inhibitory function, and (4) sensory function. The speed of information processing is usually measured by pen and paper tests where individuals make speed-based comparisons on perceptual tasks. For example, participants are asked to make rapid same-different judgments about pairs of digits or letters. The speed of processing is measured by the number of comparisons correctly made. Older adults perform slower on these tasks than do younger adults. Salthouse's research suggests that older individuals are so slow to perform early steps in many cognitive tasks that the time to perform the later operations is reduced and that the results of earlier processing are quite often lost by the time that later processing is being attempted (Salthouse, 1996). Salthouse also hypothesized that the effects of the slowed processing speed are global and impact all aspects of cognition. This could possibly explain why one rarely sees older adults on the game show *Jeopardy!*, a game where speed is a factor.

Working memory is a processing resource that can be defined as the amount of mental energy available to perform mental operations. Working memory is where we store, process, retrieve, and manipulate information (Baddeley, 1986). Memory researcher Alan Baddeley has proposed a multi-component working memory model. This model is comprised of a central

executive system and numerous subsystems referred to as slave systems (Baddeley, 1981). Two strongly related slave systems are the phonological loop – used to process auditory and speech information – and the visuo-spatial sketchpad – used to manipulate visual images (Baddeley, 1998). The phonological loop acts as short-term storage for speech-based material and as a backup for speech comprehension. It is believed to have two components – the phonological store and the articulatory control process. Information maintained in the phonological store decays in approximately one to two seconds but it can be refreshed through subvocal rehearsals which feed it back to the store (Baddeley, 1998). The articulatory control process translates visually presented material (written material) into phonological form. Evidence supports that the coding format of short-term activities tends to be phonological (sound based) even when the material to be remembered is presented in visual form (Conrad, 1964). As its name suggests, the visuo-spatial sketchpad is believed to handle visual and spatial information. This is where the image of someone's face is formed, of the way the sun looks as it is setting, or where in the room the television is located. This system is believed to assist in orientation and navigation in geographic settings (Baddeley, 1998). Working memory is tested by requesting participants to process and store information simultaneously. Quite often this is done by asking participants to hold certain numbers in memory and to perform simple addition problems at the same time. Working memory is measured by the amount of numbers held in memory and by the number of correct mathematical operations performed. In subsequent testing, Craik and Byrd (1982), concur with Salthouse, in that older adults have a more limited working memory capacity most likely due to reduced processing speed. This finding would suggest that, when designing information for older adults, it is best to keep the memory load as low as possible, a general human factor's guideline. Good environmental support for older adults could include teaching

them to use memory cues at encoding, prompts at retrieval, and to write down information that is important and could likely be forgotten.

The inhibitory function is what allows one to focus on targeted information and to inhibit or disregard other irrelevant in-coming information. Hasher and Zacks' (1988) data suggests that older adults have a much more difficult time staying focused on primary information than do their younger counterparts. Because the inhibitory function has declined, older adults are keeping a larger amount of irrelevant information in working memory - failing to prevent irrelevant information from interfering - thus reducing working memory's efficiency. Additionally, having excessive, irrelevant information in working memory also delays and complicates the encoding and retrieval processes. Further research by Hasher and Zacks (1997) also suggests that inhibition plays a role in language production situations. This was most evident when individuals had to inhibit a particularly strong response. This diminished inhibitory function could explain some older adult behaviors such as the comment, "I've lost my train of thought," or situations where they find themselves in a room having forgotten why they walked to that room in the first place.

The sensory function refers to visual and auditory acuity. The reduction in visual and auditory acuity is certainly stereotypical of older individuals as complaints of decline in these areas are heard as early as mid-life. Working with a group of participants age 25 to 103, researchers Baltes and Lindenberger (1997) found strong evidence of sensory decline that was based on biology and not on social factors such as education, occupation, or income. While studies by Cherry and Park (1993) indicate that educated individuals have higher levels of cognitive resources to begin with, Baltes and Lindenberger's research shows that rates of decline follow the same downward slope regardless of the level of education. While the decline appears

to be uniform across age groups, the individuals who start off with more resources should fare better over time. While Lindenberger and Baltes' work (1994) shows a strong connection between sensory functioning and intelligence in old age, the authors also suggest that it is a crude measure of brain integrity on its own (1994). Yet, in a 1988 study concerning bus drivers, it was found that the drivers who were between the ages of 60-64 had better safety records and fewer accidents than any other age group (Prenda & Stahl, 2001). Further research is always encouraged, yet there appears to be good evidence to support Salthouse's hypothesis that speed of processing, working memory, inhibition, and sensory function all show decline with age.

### Memory Declines

Studies show that not all types of memory show equal age deficits. Performance on some memory tasks drop considerably more than on others and understanding this differential loss provides the framework on which to build compensation techniques (Dixon & Backman, 1995). The long-term memory sub-systems, episodic and semantic memory, appear to be the areas of memory that show the most decline as humans age. Episodic memory is the ability to remember specific autobiographical events. Memory researcher Tulving (1972) defines episodic memory as memory for specific events that is defined by the time, environment, and mood state in which the information was encoded. For example, if one is questioning whether or not they did some reading before going to bed last night, it is not sufficient enough to remember what reading is or that they do usually read before retiring. It is necessary that they are able to remember last evening's "episode" – to put all of this information in the context surrounding the event in question. Episodic memory is time- and place- specific. Older adults will quite often complain about this ability to recollect these specific autobiographical events and research strongly

indicates that older adults do perform lower on episodic-memory tasks than do younger ones (Craik & Jennings, 1992; Smith, 1996). Researchers suggest that older individuals experience depletion in mental energy and diminished attentional capacity. Successfully storing something into memory needs to be an intentional act, memories are not magically made. Also, episodic memory is resource demanding, requiring adequate blood supply and blood glucose to specific areas in the brain and strong interconnections among neurons in the central nervous system (Wickens, 1984).

The evidence appears strongly to indicate that performance in testing situations declines with age. In an experiment conducted by the Wellcome Brain Research Group, School of Psychology at the University of Saint Andrews in the UK, researchers reported that the younger group of participants significantly out-performed the older group – 77% correct responses versus 43% - in a recall exercise (Mark & Rugg, 1998). Thus, the group concluded that these findings continued to be consistent with the belief that the ability to retrieve contextual information about prior events is vulnerable as age increases. In a 1995 study by Greenhut-Wertz and Manning, younger and older participants were given lists of seven-letter sequences that they were later asked to recall by either writing the sequences down or by speaking them aloud. Not only did the older group recall fewer of the sequences but they also produced more letter sequences that were completely unrelated to the learned lists. However, there is evidence that shows that these deficits can be reduced if contextual cues are provided at either encoding or at retrieval (Craik, Byrd, & Swanson, 1987). This type of environmental support was also found to boost episodic memory performance for all age groups (Light, 1991).

Semantic memory refers to factual knowledge that is stored and it is different from episodic memory as when and where the knowledge was learned is not of any relevance.

As with episodic memory, it was Tulving (1972) who first classified semantic memory as a separate memory system. Many aspects of semantic memory are found to stay intact well into old age as demonstrated by typical IQ tests (Salthouse, 1982). However, there are two specific areas where semantic memory decline is evident. The biggest semantic memory failures in an aging memory seem to be word-finding failures and failures in retrieving names (Cohen & Faulkner, 1986). Like episodic memory tasks, word- and name- finding are also very specific searches. The fact that declines in these two memory subsystems are indicative of declines in the ability to retrieve specific information may offer some assistance in establishing a pattern of over-all memory decline in general.

Research on semantic memory in older adults indicates that memory for object names and proper names learned earlier, rather than later, in life is far superior. Studies have found that information originally learned between the ages of 10 and 30 was more easily recalled than information learned between the ages of 30 and 50 (Worden & Sherman-Brown, 1983). Further research shows that older adults are much better at recalling the names of items that were in common use in the years when they were younger compared to the names of items that were in common use in their later years (Worden et al., 1983). Interestingly, Worden and colleagues' research shows that young adults exhibited exactly the opposite pattern. Thus indicating that age seems to be a factor concerning which item names are more readily recalled.

### Aging and Memory Skill Acquisition and Maintenance

Memory researchers Ericsson and Chase have proposed that memory is a skill quite similar to other skills in that it is acquired and developed (Ericsson, 1985). There are many documented studies on individuals who have superior or expert memory and the findings reveal



that these individuals are quite average in every other aspect of their lives (Bedard & Chi, 1992; Chi, Glaser, & Farr, 1988). They appear to be intellectually, emotionally, and socially ‘average,’ yet they possess expert domain-specific knowledge – knowledge that they have intentionally acquired, stored, and can easily retrieve. Additionally, studies by Ericsson and Staszewski (1989) indicate little difference in performance between subjects who claim exceptional abilities and subjects who have acquired exceptional abilities through practice. While memory ability is a complex skill, Ericsson and Chase propose that it is a skill that can be acquired through enhanced encoding and through practice. “There is no reason to believe that exceptional memory performance is possible only for a small number of special individuals” (Ericsson & Faivre, 1988, p. 392).

The skilled memory theory proposes that the improvement of memory skills is due to ‘the acquisition of more efficient storage and retrieval processes using long-term memory’ (Ericsson, 1985). Its guiding principles are:

- Information rapidly stored in long-term memory is encoded in terms of knowledge structures in semantic memory (meaningful encoding).
- During storage in long-term memory, special retrieval cues are associated with the memory encoding of the presented information (retrieval structures).
- Encoding and retrieval can be sped up by practice, making the rate of information storage in long-term memory comparable to that of short-term memory (Ericsson, 1985).

To provide the thumbnail sketch – make the information to be remembered relevant to something already known – encode it in such a way that it can be associated (attached) to something already learned and stored in memory, and then practice its retrieval.

Short-term memory/long-term memory models assume that recently perceived information is initially processed in short-term memory. Short-term memory acts as an intermediate and temporary stage before storage in long-term memory. Short-term memory has a very limited capacity and a believed storage time of approximately 30 seconds (Searleman et al., 1994). However, short-term storage can be maintained indefinitely if the information is rehearsed over and over again. This rehearsal will keep the information active and will also increase the possibility that the information will be transferred into long-term memory. By associating new information in short-term memory either with each other or with preexisting knowledge, a memory trace is formed in long-term memory. This memory trace tags (encodes) the new information for retrieval when needed in the future (Miller, 1956). If new information is not processed in this way, it will fall out of short-term memory, referred to as memory decay.

George Mandler recognized that encoding of information is enhanced when the information is organized or grouped together because of some shared relationship (Searlemann & Herrmann, 1994). This grouping of information need only have meaning or distinction to the person doing the encoding. George Miller (1956) first coined the term *chunk* as the unit of information stored in short-term memory. A chunk is a meaningful group of information (Searleman et al., 1994). Chunks can be single letters or digits or they can be groups of letters and strings of words. This combining of elements extends the capacity of short-term memory. It allows more information to be stored. After testing numerous subjects on the ability to recall various lists of letters, digits, and words, he concluded that people can store seven – plus or minus two – chunks in short-term memory.

When engaging in the process of *chunking*, the organizing of the information to be remembered is occurring. The new pieces of information are being grouped into chunks that are

related in some way and this grouping, this chunking, enhances encoding by reducing the amount of material to be processed and stored. This enhanced encoding should hopefully lead to easier retrieval. These theories of encoding information in a meaningful way, drawing on already existing knowledge, and organizing the information into related chunks, appear consistently throughout the literature on memory (Restak, 1997; Craik, Byrd & Swanson, 1987).

### Mnemonics and their strategic uses

Borrowing its name from the ancient Greek goddess of memory Mnemosyne, mnemonics are devices that aid memory. They range from simple informal memory jogs to more sophisticated strategies based upon a pre-established set of memory aids. Regardless of the intensity of the strategies, the purpose of enlisting mnemonics is to associate a new piece of information to one already known, which in turn will assist in retrieval of the new information. Mnemonic associations are most effective when they use content that is personally meaningful. However, making associations that are humorous, nonsensical, or highly arbitrary can still be effective (Collson & Mehring, 1990). Scruggs and Mastropieri (1990a) define a mnemonic as “a specific reconstruction of target content that is intended to tie new information more closely to the learner’s existing knowledge base and therefore facilitate retrieval.” The strengths of mnemonic strategies are:

- The material to be remembered is practiced repeatedly.
- The material is integrated into an existing memory framework.
- The device provides a means of retrieving the information (Ashcraft 1994, p.199).

Mnemonic devices can be categorized in two different ways: informal/naïve or formal/technical (Searleman et al., 1994; Neath, 1998). Informal/naïve mnemonic techniques are ones that require no formal training to use. They tend to be self-generated and develop spontaneously without instruction. They can be visual or verbal. Common examples of these are rhymes, acronyms, acrostics, and first-letter mnemonics (Higbee, 1996). *Thirty days hath September* is a most familiar mnemonic rhyme that aids in remembering the number of days in each month of the year. Remembering the Great Lakes by remembering the word HOMES is an example of a common acronym and every good elementary student knows that the acrostic *Every Good Boy Deserves Favor* will earn him favor in music class.

Formal/technical mnemonics are not self-generated and must rely on a preliminary learning stage before they can be applied (Neath, 1998). The method of loci, peg system, and link (or link-story) mnemonics are common technical mnemonic strategies. The loci system first requires the memorization of a series of mental images of familiar locations in a logical order, followed by associating a visual image of each item to be remembered with a location in the series (Neath, 1998). At the time of retrieval, one takes a mental walk through the location retrieving the information attached/associated with the familiar images of the location. The peg system is a series of pre-memorized concrete nouns and corresponding numbers (Neath, 1998). It is a rhyming system requiring that each of the peg-word objects be pictured quite vividly. The peg-words act as mental pegs on which to 'hang' the items to be remembered. To recall the items in order, it is necessary to recall the peg-words and retrieve the items associated with them (Baddeley, 1998, 134; Klatzky, 1975, 243). (More detail of this process is explained later in this writing.) Link mnemonics involves the forming of a visual image for each item to be remembered and then visualizing a link between each item in succession (Battig & Bellezza,

1979). A highly vivid image is necessary to trigger the association and the goal is for the first item to be visually linked to the second, the second to the third, and so on (Puff, 1979; Searleman et al., 1994). Link-story mnemonics do this by developing a story to link the related items together.

Individuals who possess exceptional memory ability do, in fact, use technical mnemonic strategies and research indicates that the use of technical mnemonics will greatly aid memory performance. Yet research also shows that people do not use technical mnemonic strategies on a regular basis in their everyday lives; they are much more likely to use informal/naïve mnemonics and external memory strategies such as the use of calendars and note-writing (Harris, 1980; Intons-Peterson & Fournier, 1986).

By introducing the use of rhyming and singing, Scruggs & Mastropieri (1990b) demonstrated the effectiveness of mnemonics in students with learning disabilities. By teaching the students a song with numbers that involved tapping certain fingers when specific numbers were said, students were able to learn the multiplication table for the number seven by learning a rhyming song which had the multiples in its lyrics. After five training sessions followed by 15-minutes of free time, the students increased their division scores by 100%. The mnemonic technique was learned quickly and effectively and should work equally as well with other songs for other mathematical facts.

In a 1999 study by Hwang, Renandya, Levin, Levin, Glasman, & Carney, a mnemonic method of associating numerical information (specifically historical dates) with illustrated pictures was introduced to two separate groups – elementary school students and college students. The 1700s, 1800s, and 1900s were identified by pictures that incorporated people who are stereotypical of different centuries. For example, the 1700s were pictured with royalty, the

1800s with cowboys, and the 1900s with astronauts. The researchers also introduced a second part of a picture for each decade and a seasonal setting to represent each month. This method was taught to the students to assist them in remembering inventions and their dates. The results indicated that both groups of students benefited from the use of this mnemonic strategy.

Treat and Reese (1976) reported on the effect of using imagery when attempting to memorize word pairs. In a test with one group of individuals (mean age 29) and a second group of individuals (mean age 69), Treat and Reese divided the participants into three groups – one which received no imagery directive, one in which the experimenters provided the imagery, and the third which was directed to generate their own images. Both age groups benefited from the imagery instruction, especially when the imagery was self-generated. It was concluded that the older group was equally as capable as the younger group in generating and using imagery to assist in remembering word pairs, yet the older group did require a longer retrieval time.

McNamara and Scott (2001) trained a group of 21 individuals, ranging in age from 17 to 45 years, the link-story memory strategy in hopes of increasing the participants' ability to recall a list of words. The experiment showed improvements from pretest to posttest for both the control group and the group taught the strategy. However, the group trained in the strategy recalled more words than did the control group and the predicted interaction between test and condition was reliable. In a similar study, Bower and Clark (1969) found that participants using the link-story strategy were able to recall 93% of the word list compared to 13% recall for the individuals not using the strategy.

In a study by Ross and Lawrence (1968), subjects were instructed to learn a set of 40 campus locations as their loci. They were then given a list of 40 items to learn using the method of loci mnemonic device. Items were presented about one every 13 seconds and a recall test

immediately followed. The average performance using the method of loci was 38 out of 40 items remembered all in the correct order. On the following day, a subsequent recall test was given and the subjects averaged 34 items remembered in the correct order.

Turner (1992) trained 34 old (mean age 69.5) and 34 young (mean age 22.8) with the method of loci strategy. The subjects were presented with four different memory tasks: word (series of words were read and recalled), sentence-word (series of sentences were read aloud, verified as to whether each sentence made sense, and sentence-last-words recalled), operation-word (arithmetic operations were read aloud, answers verified, and the word following each operation recalled), and line-shape (a pair of lines were identified as same/different and the shapes following the lines recalled). Results showed that mnemonic strategy training was useful for the old as well as the young.

The most common peg-word rhyme is Higbee's Number-Letter Mnemonic (1988). A person must first learn the peg-word rhyme which uses the digits one to ten to rhyme with:

One is a bun  
Two is a shoe  
Three is a tree  
Four is a door  
Five is a hive  
Six is sticks  
Seven is heaven  
Eight is gate  
Nine is line  
Ten is hen

Once this is learned, it can be used to learn a list of ten other items by taking each item and imagining it interacting with the item associated with the corresponding number. For example, the list to be remembered is: love, car, and soup. One could imagine a hamburger bun in the shape of a heart for the word love. The image of a big old sneaker with wheels on it with oneself driving it could be the peg-word for car and a tree with cans of Campbell's tomato soup dangling

from its branches could act as the peg for soup, etc. Baddeley (1998, p. 135) states that, “most people find that they can get virtually all the items correct after a single trial, considerably more than you would expect if you were not using mnemonics.”

Bower and Springston (1970) conducted an experiment in which subjects were asked to recall a list of letters which were spoken aloud to them. Initially the speaker separated the letters by brief, but equal pauses and tested the participants recall. On the subsequent test, the speaker chunked the letters into more meaningful groups, pausing longer after each group. Even though the letters spoken in each test were in the same sequence, the delivery of the list in the chunked form produced greater recall. (T V F B I J F K Y M C A as opposed to TV FBI JFK YMCA) (Bower & Springston, 1970).

The benefits of enlisting the use of mnemonic memory strategies runs consistently throughout the literature and for the most part, these strategies are easy to learn and to use. In the context of this research, it is important to focus on simple mnemonic strategies as the more advanced technical ones are complicated, requiring prior, extensive learning to use, thus defeating the proposed purpose – to aid the slower-processing, aging memory. While they can be viewed as crutches or tricks in aiding memory, we know they work and the complaints of declining memory could possibly be reduced if these simple strategies were to be incorporated in an individual’s approach to memorizing.

### Statement of Hypothesis

As stated previously, the overall purpose of this investigation is to foster a greater understanding of age-related memory ability as it pertains to the aging workforce’s ability to remain productive and effective in a time of complex change and some adjustments that can be



made to compensate for these memory declines. With this in mind, the specific intent of this current project is to test one premise of Ericsson and Chase's Skilled Memory Theory, namely that memory skill is a skill that can be developed through enhanced encoding and through practice. It is predicted that memory should be improved by introducing subjects to the simple mnemonic strategy of chunking the material to be memorized. This will be done with the use of six separate groups of older individuals utilizing study time and recall of a list of terms as measures. One group will simply be asked to memorize the list to the best of their ability; the second group will be introduced to the strategy of chunking and the third group will be given the word list already in a chunked form. These groups will all be given a study time of one minute. The second three groups will be instructed in the same way, but will be given a study time of two minutes.

By utilizing the chunking strategy, it is hypothesized that (1) recall will be higher for both chunking groups than for the no-strategy group due to the acquisition of more efficient storage and retrieval processes using long-term memory. Also, because older individuals take longer to process and learn a new task, (2) the group given the longer study time should outperform the group given the shorter study time.

## METHOD

### Participants

All subjects were recruited from the Ormond Beach Senior Center, Ormond Beach, Florida. They were randomly assigned to instructional groups in the order in which they volunteered for the experiment. There were 76 participants between the ages of 50 and 89, with the mean age of 69.5 years. Seventy-five percent reported being high school graduates and seventeen percent were college graduates. Eighteen percent believed they were in excellent health and forty-five percent indicated good health with fifty-nine percent of all participants exercising at least twice per week. Fifty-four percent reported a chronic health condition with high blood pressure leading the pack at thirty-seven percent.

Participants were randomly assigned to one of two groups (each group having a different study time allotment) and then within these two groups, three groups were randomly assigned. Group one – no instructions on mnemonics (control group), treatment one – general information on memory strategies, and treatment two - receive information on chunking as well as the word list already in a chunked form.

A second group of younger individuals was added for comparison to the older group and to serve as a manipulation check to verify the testing method. There were 38 participants in this group ranging in age from 19 to 47, with a mean age of 22.9 years. They were all undergraduate students at Embry-Riddle Aeronautical University. As with the older group, this group was randomly assigned to a treatment group and the experiment was run in the same manner.

## Materials

A list of twenty-four concrete nouns having the same frequency of use rating (50.26) and the same imageability rating (6.82) were chosen from Paivio, Yuille, and Madigan's (1968) list of values of 925 nouns. As indicated above, for logistic purposes, the participants were initially divided into two equal groups. Each of these two groups consisted of three sub-groups. The treatment of each of the original two groups was the same except for the amount of time given for study. For the first two sub-groups, the nouns were typed doubled-spaced in two columns on a single sheet of paper (see appendix A). For the third sub-group, the nouns were typed in the same order, yet the spacing was such that it divided the list into eight groups of three words each (see appendix B). All lists were typed in lower case letters in black ink in a size 14-font.

## Design

A 3 X 2 between subjects, fully factorial ANOVA was used to examine recall and time allotted in all groups. A between subjects design was chosen to prevent the practice effect that could occur if each group were given the same instructions. The independent variables were the form of instruction (none, information about chunking, or specific information on chunking and an already chunked list) and the time allotted to study. The dependent variable was the correct number of recalled items. The group that was instructed to try to remember as many words as they could served as the control.

## Procedure

The researcher introduced herself and indicated that the exercise which the participants were about to partake in would assist in a thesis study. They were asked not to communicate

with each other and not to read anyone else's information. They were also asked to look only at the sheet of paper that the researcher was addressing at the time – not to look ahead of the current sheet. Each participant was provided with a manila packet that contained (1) a sheet of paper with four words (see appendix C) typed in the same size as the word list was typed in to ensure that all volunteers would be able to read the list, (2) a consent form (see appendix D), (3) a copy of the Wechsler Adult Intelligence Digit/Symbol test (see appendix E), a general test of intelligence used to screen for the participants ability to act purposefully and to think rationally (Wechsler, 1981), (4) a demographic-gathering worksheet (see appendix F), and (5) one of three possible instruction sheets (see appendix G, H, I) which were all attached to the outside of the envelope. Inside the envelope was (1) the word list (either equally spaced or chunked), (2) a page with sixteen simple addition problems (see appendix J), (3) a piece of paper for testing recall of the word list, and (4) a debriefing form (see appendix K). After completing the consent form and the demographic worksheet, the researcher asked if there were any questions and if the group was ready to begin. Participants were instructed to read the instruction sheet that was attached to the outside of the envelope and to raise their hand if they had any questions. The researcher approached each individual to quietly discuss their question. Participants were instructed to remove the contents of the envelopes which had the remaining pieces of paper stapled together. The word list was on the top. The participants were instructed to begin and the clock was set for one-minute. At the end of the minute, the participants were instructed to turn to the next page of the packet and to be sure that the word page was tucked underneath. Participants were then asked to complete the addition problems that were provided on the next sheet of paper. After allowing approximately one minute for these calculations, participants were instructed to turn to the blank piece of paper and to write down every word that they

remembered from the word list that they were asked to memorize. They were given one minute for this exercise. The researcher then read the debriefing form and requested that participants sign and date it. The researcher then indicated that some of the participants may have one more sheet of paper in their packet and would they complete that sheet as well. All participants were then asked to place the packet back in the envelope. The extra sheet of paper was only in the control group's packet. This sheet asked if they had, in fact, enlisted any memory techniques when they were attempting to learn the word list. They were given a choice of some common techniques to choose from and a space to indicate 'other' (see appendix L). Participants were asked to verify that all paperwork was back in the envelope before they were thanked for their participation and dismissed. The procedures for the second group were the same except they were given a two-minute study period for the word list.

## RESULTS

Effectiveness of Time and Treatment on Adult Memory

Results of an ANOVA model failed to reveal significant differences between treatment groups ( $F(5,76) = .185$ ,  $p > .05$ ,  $\eta^2 = .06$ , power = .09). The same model was run for the younger group and the results were also not significant ( $F(5, 38) = 2.35$ ,  $p = .06$ ,  $\eta^2 = .16$ , power = .68). Further analysis indicates that for the model to be significant for the younger group, each cell of the experimental design would need 18 participants. See Tables 1 and 2 for the means and standard deviations for each age group.

**Table 1 Performance Means and Standard Deviations of Older Adult Group**

	Control	Treatment #1	Treatment #2
<b>1-Minute</b>	7.58	7.77	7.25
<b>Study Time</b>	(3.4)	(3.5)	(3.4)
<b>2-Minute</b>	7.0	8.0	8.08
<b>Study Time</b>	(3.2)	(2.5)	(4.4)

**Table 2 Performance Means and Standard Deviations of the Younger Group**

	Control	Treatment #1	Treatment #2
<b>1-Minute</b>	10.66	8.16	7.6
<b>Study Time</b>	(1.9)	(2.1)	(2.4)
<b>2-Minute</b>	11	13.14	13.43
<b>Study Time</b>	(3.2)	(5.0)	(4.9)

### Relationship Between Age, Work, and Performance

A negative relationship was indicated between age and performance – as age increases, performance decreases ( $r = -.34$ ,  $p < .01$ ). There was also a significant difference indicated in group means between the individuals who are working (mean = 10.42,  $sd = 3.75$ ) and those who are not (mean = 7.08,  $sd = 3.17$ ), as indicated by  $F(1,75) = 10.56$ ,  $p < .05$ .

### Overall Difference in Recall Between Older Group and Younger Group

Results of an independent sample t-test indicated a significant difference between performance means of the two groups ( $t = -4.42$ ,  $p < .01$ ). The older group's performance mean was 7.61 (3.47) and the younger group's mean was 10.89 (4.24).

### Strategies of the Older Control Groups

After testing, participants in the control group were asked to report any memory strategies they employed. Of the 26 participants in the older control groups, the following strategies were reported:

- Repeated the words over and over: 11
- Grouped like words together: 4
- Broke the list into chunks: 3
- Made a rhyme: 1
- Used visualization: 1

## DISCUSSION

Results of the present study failed to support the proposed hypothesis that recall for the groups directed to use the chunking strategy would outperform the non-strategy groups. For the older group, results also failed to support the hypothesis that the group given the longer study time would outperform the group given the shorter study time. The lack of support for the proposed hypotheses could have been the result of several causes.

First, it could possibly be that advancing age, in itself, overrides any possibility for the experiment to show effect. More than half of the individuals in the older group were over the age of seventy-four. Thirty-seven percent of them believed their health to be less than good and fifty-four percent indicated chronic health conditions and the need for numerous medications.

Second, a large amount of error was observed in the naturalistic setting in which the experiments occurred. The experiment's participants were highly distracted by other events that were occurring simultaneously, they often failed to heed the researcher's directions to stay focused on their own test, and some of them continued on the study task after being instructed to proceed to the next section. In this type of environment, the researcher had limited control.

Third, it is possible that repeated study sessions over time may show the desired effect. The literature shows that simple mnemonic strategies are most often learned quickly and effectively, yet this is not what was observed in this study (Searleman et al., 1994; Neath, 1998, Higbee, 1996). However, interestingly enough, many of the participants in the groups that were trained in the chunking strategy, wrote down their responses in chunked form, thus suggesting that they did learn the strategy, but that the strategy did not help to improve their recall amounts. It would be of interest to see if repeated learning sessions would eventually improve the recall scores by reinforcing the learning of the strategy.



With the weaknesses of this study noted, it would be most interesting to modify the ones that are possible and to observe any performance changes. Namely, it would be of great value to attempt better control of the testing environment. Rather than running the experiment in a recreational environment, a small testing laboratory would be more desirable. While the participants knew ahead of time that a researcher would be coming to their event and would be asking for their voluntary participation in a study, it would be more beneficial to have the volunteers come to the testing site for the specific purpose of partaking in an experiment. In a naturalistic, recreational setting the motivation to fully engage in the experiment was minimal.

In a better-controlled environment, it would be interesting to see if the present study would result in findings that would support the current hypotheses. With our society presently being demographically older than any we have ever known and with the increase in the number of workers over the age of 65, designing information for older adults is quite important. Aging individuals – in the workforce or not – would certainly benefit from learning any strategy that would help to compensate for memory declines and a chunking strategy could possibly be one of these.

## Appendix A

### Word List

coffee

arrow

garden

letter

valley

paper

salad

barrel

slipper

forest

bottle

hammer

lake

chair

meadow

ocean

storm

window

potato

meat

elbow

magazine

trunk

girl

## Appendix B

### Chunked List

coffee

arrow

garden

letter

valley

paper

salad

barrel

slipper

forest

bottle

hammer

lake

chair

meadow

ocean

storm

window

potato

meat

elbow

magazine

trunk

girl

## Appendix C

### Screen for Print Size

Live well

Laugh often

Appendix D  
Consent Form



Karen A.S. Doolittle, Researcher  
Dr. Christina Frederick-Recascino, Academic Advisor  
Embry-Riddle Aeronautical University  
Human Factors and Systems  
Daytona Beach, FL 32114

The experiment you are about to participate in is designed to investigate the relationship between the type of instruction given when being instructed to memorize a list of words and the amount of words that are correctly recalled. You will be given a list of words and instructed to memorize them. Next, you will be asked to solve a series of addition problems. You will then be asked to write down as many of the words on the list that you can remember. You will also be asked to provide some basic demographic information about yourself. It is requested that you do not communicate with other participants during the training and testing phase of the experiment. Your entire participation should run approximately 30 minutes.

All information that you provide will be held in confidence by the researcher and at no time will your name be reported along with your responses. There are no known risks associated with this experiment and you are free to withdraw at any time. Your voluntary participation is most appreciated by the University and by myself. Please feel free to ask any questions that you might have.

If you would like a summary of this experiment's findings, please place your request at: Karen.Doolittle@erau.edu.

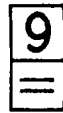
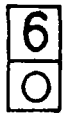
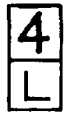
### **Statement of Consent**

I have been adequately informed of the intent of this experiment. My participation is voluntary and I understand that I may withdraw my participation at any time.

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

## Appendix E

### Wechsler Adult Intelligence Digit/Symbol Test

10. DIGIT  
SYMBOLSCORE  

## SAMPLES

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1	4

1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7	3

6	2	5	1	9	2	8	3	7	4	6	5	9	4	8	3	7	2	6	1	5	4	6	3	7

9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

## Digit Symbol Test Scoring Key

Age Group	Minimum Score
18-19	45
20-24	49
25-34	40
35-44	36
45-54	27
55-64	22
65-69	17
70-74	12
>74	9

Appendix F  
Demographic Worksheet

Age: \_\_\_\_\_

Sex: ☐ Male ☐ Female

Education:

☐ Less than high school ☐ High School ☐ Some college ☐ College graduate

How to you rate your over-all health? ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Exercise:

☐ Never ☐ Once a month ☐ Twice a month ☐ Once a week ☐ Twice a week ☐ Daily

Have you had major surgery in the past year? ☐ Yes ☐ No

Medications taken regularly:

☐ None ☐ These: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Are you currently employed? ☐ Yes, \_\_\_\_\_ (print hours per week) ☐ No

If you are not currently working, how long have you been out of the workforce:

☐ Less than two years ☐ 2-5 years ☐ 5-10 years ☐ more than 10 years

Chronic Diseases:

☐ Heart Disease ☐ High blood pressure ☐ Diabetes ☐ Other \_\_\_\_\_

## Appendix G

### Directions for Control Group

### Directions

You will be given a list of words. When instructed to do so, please look at the list and try to remember as many of them as you can.

## Appendix H

### Directions for Treatment Group #1



### Directions

You are going to be presented with a list of words to memorize.

There is no one-way to memorize things. Actually, there are many, simple memory strategies that we use all of the time. One of these strategies is to group three words together into one chunk. Sometimes it's easier to remember chunks of information than it is to remember single items. When instructed to do so, please look at the list of words and try to remember as many of them as you can.

## Appendix I

### Directions for Treatment Group #2

## Directions

You are going to be presented with a list of words to memorize. There is no one-way to memorize things. Actually, there are many, simple memory strategies that we use all of the time.

One of these strategies is to group three words together into one *chunk*. Sometimes it's easier to remember chunks of information than it is to remember single items. It is often helpful to *chunk* like-words together, but sometimes it is just as helpful to break up a list into chunks of three and put them into memory in that *chunked form*.

You are going to be presented with a list of words. They will be in chunks or groups. When instructed to do so, please attempt to memorize as many words from the list that you can.

## Appendix J

### Addition Distracter Test

Please solve the following addition problems.

$$\begin{array}{r} 68 \\ + 21 \\ \hline \end{array}$$

$$\begin{array}{r} 29 \\ + 74 \\ \hline \end{array}$$

$$\begin{array}{r} 88 \\ + 34 \\ \hline \end{array}$$

$$\begin{array}{r} 36 \\ + 71 \\ \hline \end{array}$$

$$\begin{array}{r} 52 \\ + 17 \\ \hline \end{array}$$

$$\begin{array}{r} 78 \\ + 87 \\ \hline \end{array}$$

$$\begin{array}{r} 18 \\ + 98 \\ \hline \end{array}$$

$$\begin{array}{r} 86 \\ + 66 \\ \hline \end{array}$$

$$\begin{array}{r} 45 \\ + 19 \\ \hline \end{array}$$

$$\begin{array}{r} 22 \\ + 33 \\ \hline \end{array}$$

$$\begin{array}{r} 30 \\ + 40 \\ \hline \end{array}$$

$$\begin{array}{r} 21 \\ + 89 \\ \hline \end{array}$$

$$\begin{array}{r} 90 \\ + 39 \\ \hline \end{array}$$

$$\begin{array}{r} 16 \\ + 44 \\ \hline \end{array}$$

$$\begin{array}{r} 31 \\ + 57 \\ \hline \end{array}$$

Appendix K  
Debriefing Form

Karen A.S. Doolittle, Researcher  
Dr. Christina Frederick-Recascino, Academic Advisor  
Embry-Riddle Aeronautical University  
Human Factors and System  
Daytona Beach, FL 32114

The experiment that you have just participated in was designed to investigate the relationship between the type of instruction given when being asked to memorize a list of words and the amount of words that are correctly recalled. You have been a participant in one of three groups with each group being given different instructions prior to being asked to memorize a list of words. The first group was asked to just remember as many words as they could. The second group was given some general information on memory strategy. The third group was given a specific strategy to use.

It is this researcher's belief that the more information an individual has concerning memory strategy the more they will be able to remember. Your participation in today's experiment will hopefully assist this researcher in evaluating the validity of this belief.

Memory failures are a major complaint in older individuals and it seems reasonable to believe that the teaching of simple memory strategies will allow for better recall of information thus hopefully reducing this growing concern. This is especially important as we are living in a society that is demographically older than any we have ever known.

Signature of Participant: \_\_\_\_\_ Date: \_\_\_\_\_

## Appendix L

### Survey of Control Group



There is no one-way to memorize something. We all have our own style and habits. When you were asked to memorize the list of words, how did you approach this?

Did you:

\*Rehearse – repeating the words over and over? ☐ yes ☐ no

\*Make up a rhyme or song with the words? ☐ yes ☐ no

\*Make up an acronym?  
(CAP to remember coffee, arrow, paper, for example) ☐ yes ☐ no

\*Group together words that began with the same letter? ☐ yes ☐ no

\*Create a story? ☐ yes ☐ no  
(The *girl* was sitting in a *chair* in the *garden* by the *lake* drinking *coffee* from a *bottle* and eating a *meat* and *potato salad* on a *paper* plate, for example.)

\*Group like words together? ☐ yes ☐ no  
(forest, lake, valley, meadow or paper, letter, magazine, for example)

\*Divide the list into three (or four) words to be remembered together in the order in which they appeared on the list? ☐ yes ☐ no  
(coffee/garden/valley.....salad/slipper/bottle.....arrow/letter/paper)

Or did you use some other strategy? Please explain:

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## REFERENCES

- Ashcraft, M. H. (1994). *Human memory and cognition (2<sup>nd</sup> Ed.)*. NY, NY: Harper Collins College Publishers.
- Baddeley, A. (1981). The concept of working memory. A view of its current state and probable future development. *Cognition*, 10, 17-23.
- Baddeley, A. (1986). *Working memory*. Oxford, England: Clarendon Press.
- Baddeley, A. (1998). *Human memory: theory and practice*. Boston, MA: Allyn and Bacon.
- Baltes, P.B., & Lindenberger, U. (1997). Emergence of powerful connection between sensory and cognitive functions across the adult life span: A new window to the study of cognitive aging? *Psychology and Aging*, (12), 12-21.
- Battig, W. & Bellezza, F. (1979). Organization and levels of processing. In C.R. Puff (Ed.), *Memory organization and structure*. NY, NY: Academic Press, Inc.
- Bedard, J. & Chi, M.T.H. (1992). Expertise. *Current Directions in Psychological Science*, 1, 135-139.
- Bower, G.H. & Clark, M.C. (1969). Narrative stories as mediators for serial learning. *Psychonomic Science*, 14, 181-182.
- Bower, G.H. & Springston, F. (1970). Pauses as recoding points in letter series. *Journal of Experimental Psychology*, 83, 421-430.
- Bushko, D. & Raynor, M. (1999). More on the aging worker: who are they and how can they stay vital? *Journal of Management Consulting*, 10, 3, 68-69.
- Carstensen, L. L. (2 Jan 2001). On the brink of a brand-new old age. *New York Times*, late edition/east coast, A.15.
- Cherry, K.E. & Park, D.C. (1993). Individual differences and contextual variables influence spatial memory in younger and older adults. *Psychology and Aging*, (8) 517-526.
- Chi, M.T.H., Glaser, R. & Farr, M.J. (Eds.) (1988). *The nature of expertise*. Hillsdale, NJ: Erlbaum.
- Cohen, G. & Faulkner, D. (1986). Memory for proper names: age differences in retrieval. *British Journal of Developmental Psychology*, 4, 187-197.
- Collson, S. & Mehring, T. (1990). Facilitating memory in students with learning disabilities. *LD Forum*, 16, 75-79.

- Conrad, R. (1964). Acoustic confusions in immediate memory. *British Journal of Psychology*, 55, 75-84.
- Craik, F.I.M. & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. *Aging and cognitive processes*, 191-211. New York: Plenum Press.
- Craik, F.I.M., Byrd, M. & Swanson, J.M. (1987). Patterns of memory loss in three elder samples. *Psychology and Aging*, 2, 79-86.
- Craik, F.I.M. & Jennings, J.M. (1992). Human Memory. In F.I.M. Craik & T.A. Salthouse (Eds.), *The handbook of aging and cognition*, 51-110; Hillsdale, NJ: Erlbaum Associates.
- Dixon, R.A. & Backman, L. (1995). *Compensating for psychological deficits and declines: Managing losses and promoting gains*; Mahwah, NJ: Erlbaum Associates.
- Ericsson, K.A. (1985). *Memory Skill*. Canadian Journal of Psychology, 39 (2), 188-231.
- Ericsson, K.A. & Faivre, I.A. (1988). What's exceptional about exceptional abilities? In L.K. Obler & D. Fein (Eds.), *The exceptional brain: Neuropsychology of talent and special Abilities*, 392. NY, NY: Guilford.
- Ericsson, K.A. & Staszewski, J. (1989). Skilled memory and expertise: Mechanisms of exceptional performance. In D. Klahr & K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon*. Hillsdale, NJ: Erlbaum.
- Greenhut-Wertz, J. & Manning, S.K. (1995). Suffix effects and intrusion errors in young and elderly participants. *Experimental Aging Research*, 21, 173-190.
- Harris, J.E. (1980). Memory aids people use: Two interview studies. *Memory and Cognition*, 8, 31-38.
- Hasher, L. & Zacks, R.T. (1988). Working memory, comprehension, and aging: A review and a new view. *The psychology of learning and motivation*, (22), 193-225. San Diego, CA: Academic Press.
- Hasher, L. & Zacks, R.T. (1997). Cognitive gerontology and attentional inhibition: A reply to Burke and McDowd. *Journal of Gerontology: Psychological Sciences*, (52), 274-283.
- Higbee, K.L. (1996). *Your memory: how it works and how to improve it (2<sup>nd</sup> Ed)*, 94. NY, NY: Marlowe & Company.
- Hwany, Y., Renandya, W.A., Levin, J.R., Levin, M.E., Glasman, L.D. & Carney, R.N. (1999). A pictorial mnemonic numeric system for improving students' factual memory. *Journal of Mental Imagery*, 23, 45-70.

- Inton-Peterson, M.J. & Fournier, J. (1986). External and internal memory aids: When and how often do we use them? *Journal of Experimental Psychology: General*, 115, 267-280.
- Klatzky, R.L. (1975). *Human memory; structures and processes*. San Francisco, CA: W.H. Freeman & Co.
- Light, L. L. (1991). Memory and aging: Four hypotheses in search of data. *Annual Review of Psychology*, 42, 333-376.
- Lindenberger, U. & Baltes, P.B. (1994). Sensory functioning and intelligence in old age: A strong connection. *Psychology and Aging*, (9), 339-355.
- Lofgren, E. (Winter 1999). Workforce management is new discipline for the future. *Compensation & Benefits Management*, 15, 1, 13-18.
- Mark, R.E., Rugg, M. (1998). Age effects on brain activity associated with episodic memory retrieval: an electrophysiological study. *Brain*, 121, 861-887.
- McMahon, S., Phillips, K. (1999). America's aging workforce: ergonomic solutions for reducing the risk of CTDs. *American Journal of Health Studies*; 15, 4, 199-202.
- McNamara, D.S. & Scott, J.C. (2001). Working memory capacity and strategy use. *Memory and Cognition*, 29 (1), 10-17.
- Miller, G. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *The Psychological Review*, 63, 81-97.
- Morrell, R.W. & Echt, K.V (1996). Instructional design for older computer users: the influence of cognitive factors. In W.A. Rogers, A.D. Fisk & N. Walker (Eds.), *Aging and skilled performance: advances in theory and application*; Mahwah, NJ: Erlbaum Associates.
- Nayer, C. (1997). Managing the aging workforce. *AWHP's Worksite Health*, Spring edition, 20-22.
- Neath, I. (1998). *Human memory; an introduction to research, data, and theory*, 383-386. Pacific Grove, CA: Brooks/Cole Publishing Co.
- Paivio, A., Yuille, J.C., & Madigan, S. (1968). Concreteness, imagery, and meaning fullness values for 925 nouns. *Journal of Experimental Psychology Monograph Supplement*, 76 (1, pt 2), 1-25.
- Peterson, P.G. (2001). A graying world. *Harvard International Review*, 23, 3, 66-75.
- Prenda, K.M. & Stahl, S.M. (2001 May). The truth about older workers. *Business and Health, Montavale*, (19), 5, 30-37.

- Puff, C.R. (1997). *Memory, organization, and structure*, 331-333; NY, NY: Academic Press.
- Restak, R.M. (1997). *Older and wiser: how to maintain peak mental ability for as long as you Live*, 95; NY, NY: Simon & Schuster.
- Rogers, W.A. & Fisk, A.D. (2000). Human Factors, Applied Cognition, and Aging. In F.I.M. Craik & T.A. Salthouse (Eds.), *The handbook of aging and cognition*, 569; Mahwah, NJ: Erlbaum Associates.
- Ross, J. & Lawrence, K.A. (1968). Some observations on memory artifice. *Psychonomic Science*, 13, 107-108.
- Salthouse, T.A. (1982). *Adult cognition: An experimental psychology of human aging*. New York: Springer-Verlag.
- Salthouse, T.A. (1991). *Theoretical perspectives on cognitive aging*. Hillsdale, NJ: Erlbaum.
- Salthouse, T.A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, (103), 403-428.
- Scruggs, T.E. & Mastropierei, M.A. (1990a). The case for mnemonic instruction: From laboratory research to classroom applications. *The Journal of Special Education*, 24, 7-29.
- Scruggs, T.E. & Mastropierei, M.A. (1990b). Mnemonic instruction for students with learning disabilities: What it is and what it does. *Learning Disability Quarterly*, 13, 271-280.
- Searleman, A. & Herrmann, D. (1994). *Memory from a broader perspective*, 73, 290, 352-358; Boston, MA: McGraw-Hill.
- Smith, A.D. (1996). Memory. In J.E. Birren & K.W. Schaie (Eds.), *Handbook of the psychology of aging*, 236-250; San Diego, CA: Academic Press.
- Treat, N.J. & Reese, H.W. (1976). Age, pacing, and imagery in paired-associate learning. *Developmental Psychology*, 12, 119-124.
- Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization and Memory*, 381-403; NY, NY: Academic Press.
- Turner, M.L. (1997). Memory performance as a function of age, reattribution training, and type of mnemonic. In W.A. Rogers (Eds.), *Designing for an aging population*, 159-163; Santa Monica, CA: Human Factors and Ergonomics Society.
- Wechsler, D. (1981). *Wechsler Adult Intelligence Scale – Revised*. San Antonio, TX: The Psychological Corporation.

- Wickens, C.D. (1984). Processing resources in attention. In R. Parasuraman & D. R. Davies (Eds). *Varieties of attention*, 63-102; Orlando, FL: Academic Press.
- Worden, P.E. & Sherman-Brown, S. (1983). A word-frequency cohort effect in young versus elderly adults' memory for words. *Developmental Psychology*. 19, 521-530.